Impact of News Announcements on Carbon Prices

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Abstract

Carbon markets play a crucial role in the global energy markets and towards the climate goals, yet the understanding of how international climate related news shape the liquidity in this market is important for market participants. Comparing to existing studies that focuses on a single category of news, this paper provides a complimentary reference on if and to what extent announcements can impact the carbon prices by classifying the news in seven categories. In this paper, we examine the effect of different types of international announcements on prices in eight carbon markets around the world by running an event study on daily stock returns for spot contracts from 20 January 2015 to 30 June 2020. In general, the results showcase that news announcements have an impact on carbon prices and the type of news differs in terms of their reactions. Good news seem to have a longer effect than bad news. Similarly, the categories of news tend to influence the carbon markets differently. Carbon markets react to market reforms rather than to other announcements such as controversies, lobbying or Paris Agreement. Unlike other energy commodities, carbon allowances do not register prolonged effect post announcement nor are the news anticipated.

Keywords: carbon markets carbon pricing, event study, announcements, news sentiment

1 Introduction

The last decade has witnessed a wave of carbon markets being set up across the world (Ramstein et al., 2019). With the hopeful signs of carbon prices skyrocketing in EU ETS, the USA President's Biden election with an ambitious agenda for climate policy and China's commitment to towards carbon net zero by 2060, carbon markets shall play a pivotal role in aligning to the climate targets. While carbon markets are growing as a dominant response policy, its role on international level in particular in Article 6 of the Paris Agreement looks bleak. Given this exploratory development, carbon markets are evolving into an important financial market (Zhu et al., 2019). They are considered as a cost-effective policy instrument to reduce greenhouse gases emissions. Unlike other naturally formed market (e.g the oil market), carbon market has been regarded as a policy-oriented market in each existing emission trading scheme (ETS) around the world (Song et al., 2019). This government led mechanism is likely to be influenced by an array of supervisory systems, trading rules, international climate agreements and spillover by peer carbon markets (Newell et al., 2014). This very trait of carbon market makes it vulnerable to shocks from vital information announcements or regulations modification. It is valuable to investigate the influence channel of the different institutions of the carbon market which in turn help traders to grasp the impact and make more robust trading strategies for carbon emission credits.

The release of new information on carbon markets is considered as sporadic and numerous. The behavioural finance literature has been intensified to gauge the sentiments of news on stock markets (Baker and Wurgler, 2007; Kearney and Liu, 2014). In addition, the speed at which market participants react to news showcases the efficiency of asset prices (Duffie, 2010). As countries and regions are globally implementing carbon pricing policies, there is an understandably great interest in how these policies will impact the competitiveness, productivity and primarily the pricing in carbon markets. The impact of events or news on carbon markets have been chronically investigated in several academic papers. Miclaus et al. (2008) study the announcement related to Phase I and II of National Allocation Plans (NAPs) on the EU ETS and no evidence was found on cumulative abnormal returns. The same set of announcements have been tested by Mansanet-Bataller and Pardo (2009) and statistically significant market reactions before and after the events have been documented. Lepone et al. (2011) highlight the level of informational asymmetry and data leakage observed in the carbon market. They report cumulative abnormal returns associated with these types of institutional announcements.Chevallier et al. (2009) reports considerable impact of European Commission

disclosure on carbon price formation. Sanin et al. (2015) presents that media news can lead to a time varying price jump in carbon price for the EU ETS.

The aim of this paper is to study the impact of new information coming from international level on carbon prices and their volatility. To our knowledge, this is the first attempt to study this issue across different carbon markets around the world. So far, the effect of news across carbon markets have remained restricted to a single carbon market. Similarly, the type of news have been limited to set of supply-related announcements such as NAPs, annual releases of verified emissions data. In addition to these, this paper looks into the demand side announcements such as linkage amongst carbon markets, lobbying and controversies over carbon pricing, policy makers' ambitions and introduction of new carbon markets as well as the United Nations' Conference of Parties, particularly, the Paris Agreement. Consequently, we investigate how carbon prices react to related news announcements in order to empirically study information processing across eight carbon markets; EU, California, RGGI, Quebec, South Korea and three Chinese ETS namely Guangdong, Hubei and Shenzhen. Specifically, the study shows whether (i) News announcements on carbon markets do not affect the value of carbon prices on emission trading systems. (ii) There is no difference among types of news announcements with respect to their effect on the value of carbon prices on emission trading systems. (iii) There is no difference in the market reaction before and after news announcements. Using news derived from Bloomberg and event study methodology, our results bring forward that news announcements have an impact on carbon prices and the type of news differs in terms of their reactions. Good news seem to have a longer effect than bad news. Similarly, the categories of news tend to influence the carbon markets differently. Market reforms significantly impact on the carbon markets compared to other third party announcements such as controversies and lobbying. The oldest ETS; EU and RGGI are most impacted by the announcements than the latest ones. Further, announcements tend to have an immediate impact on carbon markets rather than a post event effect or an anticipation of such news.

The paper is structured as follows. The next section depicts in detail the type of announcements that have been considered, how the release of information is produced and when it should arrive in the market. The data and methodology have been expanded in section 3. The fourth section details the empirical results and the fifth section concludes.

2 Literature Review

2.1 Information Processing in Carbon Markets

Empirical literature on carbon pricing mechanism has been geared towards economic activities. Chevallier (2009); Gronwald et al. (2011) and the relationship between energy prices (Hammoudeh et al., 2014; Sousa et al., 2014; Tan and Wang, 2017b). Reports on the states of EU ETS and PricewaterhouseCoopers highlight importance of carbon market sentiment (Marcu et al., 2017; Ellerman and Buchner, 2008) find that carbon prices in EU ETS fell by nearly half following the publication of the first carbon verification report. Jia et al. (2016) showcase that verified emission announcements released annually for the period 2006-2013 cause shocks and increase risk of information leakage on the road to price discovery. Quantifying sentiment indicators have remained controversial in previous studies.

Existing studies related to carbon markets adopt market activity indicators to represent the sentiment. Koch et al. (2014) and Jiao et al. (2018) study the macroeconomic sentiment indicators to explain the changes in EU ETS prices. Reboredo (2014) is of view that macroeconomic and financial variables influences the oil prices which transcends to carbon markets. Zhu et al. (2018) develop a multi scale event analysis through ensemble empirical mode decomposition (EEMD) to gauge the impact of economic crises in EU ETS. Wider research have argued that regulatory changes are likely to impact on emission allowance prices (Daskalakis and Markellos, 2009; Koch et al., 2014; Kossoy and Guigon, 2012). Conrad et al. (2012) find that NAPs affect the price sensitivity during 2006 and 2007 emission announcements but did not discuss price impact in particular. The NAPs determine the total allowances to be allocated and the way allowances allocation is determined for each country that are part of a given ETS. Ye and Xue (2021) employ a carbon tone index of news on the EU ETS through the Latent Dirichlet Allocation method.

Deeney et al. (2016) use the event study and GARCH volatility method to assess the impact of EU Parliament decisions on EU ETS prices. Mansanet-Bataller and Pardo (2009) analyse 70 regulatory news announcements on carbon prices for the period 2004 to 2007 using the event study method by Mckenzie et al. (2004).The impact of trading policy on Chinese Pilot Shanghai Emission Allowance price was analysed through Mean Reversion Test, Cox-Ingersoll-Ross(CIR) model and Event Study Method(Song et al., 2018). The findings showed that trading policy affects emission allowance prices through the fundamentals of supply and demand. Hintermann (2010) and Rezaee et al. (2017) find that trading policy can result

as structural breaks in carbon prices during the first phase of EU ETS. Blyth et al. (2007) viewed the change of climate policy as an important external factor that affects the change of carbon price and later on developed a framework to identify what policy can markedly influence carbon price Blyth et al. (2009). Alberola et al. (2007) and Alberola et al. (2008) state that policy can help in price discovery function in early phases of the EU ETS. Lu et al. (2021) discover burst of price bubbles in Beijing carbon market following environmental policy announcement during the period January 2014 to April 2018 using the methodology by Phillips and Yu (2011) . Song et al. (2019) adopt a fuzzy stochastic model for carbon price prediction under the influence of demand-related policy in Chinese carbon markets. Yang et al. (2018) employ the difference-in-differences method to investigate the impact of various policies on carbon price amongst Chinese pilot carbon markets.

Chevallier (2010) studied the impact of Australian ETS news on wholesale electricity spot price using ARMA (1,1)- GARCH(1,1) model showing that ETS news tend to increase the levels and volatility of electricity spot prices. Fan and Todorova (2017) investigated the Chinese pilots' ETS and the overall sentiment of Chinaâs market (CHVIX and OVX) alongside energy prices. Zhang and Sun (2016) assessed the asymmetric shocks of positive and negative information on carbon and energy markets through dynamic conditional correlation (DCC) and GARCH method by Engle and Kroner (1995).

Event study methodology and dummy variable modelling methods are commonly adopted to appraise events of the market Jia et al. (2016). However, the latter suffers from drawback such as illustrating the impact process and pattern of the events. Impact process of events on prices can be drawn through abnormal returns calculations in the event window (Brown and Warner, 1985; Corrado, 2011; Fama et al., 1969). Horan et al. (2004) who studied OPEC news announcement on oil prices used an event window of five days pre and post announcement so as to avoid overlapping over OPEC meetings and announcements. The event window choice is not subject to any formal rules and can differ among different studies.

Thus, previous studies is largely dominated on the appraisal of the EU ETS and only a single type of news. It lacks a systematic review of the how changes in the international arena impact on the carbon markets and the emission allowance prices. By extending the categories of news beyond market policies and across eight carbon markets, this paper provides more insight on how news are perceived by market players. Further, we also investigate whether a specific type of news or resolutions have higher impact than another one.

2.2 Types of News Announcements related to Carbon Markets

Controversies and Uncertainty reigning Carbon Markets : There is a deep literature on the environmental integrity of international carbon markets notably in the Kyoto Protocol context (Erickson et al., 2014; Cames et al., 2016; Schneider and La Hoz Theuer, 2019; Greiner and Michaelowa, 2003; Spalding-Fecher et al., 2012). The issue of carbon leakage has also been flagged by existing studies (Calvin et al., 2015; Geres and Michaelowa, 2002; Kallbekken, 2007; Vöhringer et al., 2006). Based on IPCC (2014) report, the controversies over carbon markets are likely to arise from the effort in aggregate emission reduction over carbon trading. Hood et al. (2014) and Kreibich and Obergassel (2016) discussed about double counting of emission reductions in the Paris Agreement era.

The news announcements captured flag the uncertainty of carbon market to reach global consensus over Article 6 of the Paris Agreement, existing carbon markets being exposed to risks and challenges to meet the climate goals, lack of leadership and appropriate policies in the markets. Golub et al. (2017) state that the more uncertain the policies about carbon markets are, the higher the cost of future emissions is likely to be. Policy uncertainty and interconnection's of carbon market and financial markets have also been of interest to scholars. Adekoya et al. (2021) sheds light on EU ETS being net receivers of shocks from other financial market and policy uncertainty in the US is a notable driver for the connectedness. Similar results have been reinforced by Ye et al. (2021) who confirm cross correlation behaviour structure in EU ETS and economic policy uncertainty specifically from UK and the US.

Lobbying by Stakeholders of Carbon Markets: Since the implementation of the first emission trading system, diverse stakeholders have been lobbying for its effectiveness (Jevnaker and Wettestad, 2017). Over years, the performance of carbon markets have been troubling (Wettestad and Jevnaker, 2016) due to drop in emission allowance prices, oversupply of allowances, carbon leakage and more. This lead to the emergence of lobbying coalitions which is a complex matter and depend on multiple factors such as the policy problem and resources available to the interest groups (Holyoke, 2009). Carbon markets have also been subject to lobbying coalitions comprising of primarily non-governmental organisations (NGOs) that have been voicing out about the weaknesses in the system (Meckling, 2011). Secondly, businesses have also been at the forefront of lobbying on related matters. Weak official oversight of most carbon markets has also opened door to fraudulent activity by private actors. To preserve the environmental integrity of carbon markets, the price of emission allowances should reflect the real cost of reducing what is considered an additional and permanent ton of CO2

from the atmosphere. In turn, these behaviours are likely to influence the policy positions and market reforms thereby impeding on pricing (Beyers and De Bruycker, 2018). A study by Miard (2014) illustrates the different lobbying routes in the EU ETS. It differentiates between organisational forms of business interest representations ranging from individual firms lobbying directly via national associations, or in alliance with other firms or groups. Rasmussen and Alexandrova (2012) analyses the EU membership's possible influence on actors' lobbying. To the authors' knowledge, no study has investigated the impact of lobbying on carbon prices.

Linking Carbon Markets : Linkage amongst carbon markets have been on the radar of discussions since their births. Norway was linked to the EU ETS in 2009 as the first non EU scheme. Australia and EU were prying on the possibility to link their carbon trading activities as from 2018. Policy makers have also been eyeing and advocating for a global carbon market as an outcome of the Paris Agreement (Beuermann et al., 2017; Bodansky et al., 2016; Ranson and Stavins, 2016; Schneider et al., 2017). With the advent of the Paris Agreement, countries have been pushing towards a global carbon market. Article 6.2 shall give rise to the use of 'internationally transferred mitigation outcomes' whilst Article 6.4 shall establish a new crediting mechanism under international oversight (Savaresi, 2016). Carbon market linkage can have both political and economic benefits. Politically, carbon market linkage will motivate regions to achieve more ambitious emission reduction targets. To sum up, there are strong signals on linking carbon markets and on their inter-nationalisations. A report by World Bank features that global carbon market could reduce global abatement costs by one-third in 2030 and by half in 2050 (Economics et al., 2016). Alexeeva and Anger (2016) studies the trade competitiveness and welfare impacts of linking the carbon markets. The findings are in favor for EU ETS to link with other carbon markets whilst the non EU ETS are at a disadvantage as they face competitiveness losses. Ma et al. (2019) appraises linkage between China, Japan and South Korea ETS and finds that such activity can boost the transactions scale and liquidity in all three countries.

Market Reforms News Impact on Carbon Markets: Market reforms alias changes in carbon trading policies can bring a swing of stakeholders' sentiment and thereby impacting on its trading activities. There is a rich literature that study the market reforms and impact on carbon pricing, though the studies are restricted to a single market. Rezaee et al. (2017) find that market-related policy often causes the violent fluctuation of carbon price. Hintermann (2010) states that such reforms have resulted in structural breaks in the EU ETS. The results have been reflected for Chinese ETS as stipulated by Tan and Wang (2017a). The auction mechanism and allowances can impact on emission prices. Excessive allowances can weaken the

reduction targets and eventually cause the prices to collapse (MacKenzie, 2009). Lepone et al. (2011) found that National Allocation Plans (NAPs) and verified emissions announcements had significant impacts on carbon returns but had weak impacts on carbon price volatility. The construction of carbon markets have thus been a learning-by-doing process since the very beginning. It is thus imperatively that the impact of such market reforms should be gauged (Chevallier et al., 2009; Fan et al., 2017).

New Carbon Markets News : Amongst various greenhouse gas reduction practices, carbon markets are being favored by many countries in order to meet the Paris Agreement. The World Bank report on State and Trends on Carbon Pricing 2020 stipulates that there are around 61 carbon taxes or emission trading system in place or scheduled for implementation (World-Bank, 2020). China has launched its national ETS in early 2021 but have been communicating about it since the past five years. So far, there is no paper that documents the impact of launching a new ETS on existing ones. During the past five years, at least thirteen countries communicated about their plans for introducing a carbon market. In an era of increasing connectedness and spillover amongst carbon markets, there is a need to assess how market participants react to such announcement.

Paris Agreement and Carbon Markets: During the early UN climate negotiations, the scope of international investment in emission reduction projects was introduced in the form of Kyoto Protocol, adopted in December 1997 (Jackson et al., 2001). The commitments of Annex I countries were however vague and non binding. In 2016, the Paris Agreement was ratified by 196 countries. US announced its withdrawal from the Paris Agreement in June 2017 whilst on the other hand, China as the world's largest carbon emitter was on the verge of launching its national ETS (Wang and Wang, 2017). Further hindsight about this international agreement have brought along concept of international transfers, governance concerns, incentives and disincentives for raising ambition in carbon markets (Agreement, Agreement; Cames et al., 2016; Greiner et al., 2017; Klein et al., 2017; Howard et al., 2017).

Policy Makers Ambition towards Carbon Markets: Reduction of GHG emissions have become one of the major concerns of countries. Various measures have been taken worldwide to transcend to a low carbon economy (Stern and Stern, 2007). Policy makers have thus resorted to two promising mechanisms of carbon pricing which are carbon tax or emission trading system. Evidence also shows that following the devastating earthquake in 2011 in Japan, The German Chancellor Angela Markel was the first one to commit to the

suspension of multiple nuclear reactors which led to a spike in carbon prices [1]. Such evidence points out that market participants are able to accurately price in new information from policy makers. Koch et al. (2016) investigates how political process of making cap adjustments has shaped the market outcomes of the EU ETS and find that there is a high market responsiveness to political events and reveal how participants view the evolution in the light of a particular announcement.

2.3 Methods for Sentiment Analysis of News

This section provides a review of the text sentiment analysis of news in the financial markets.Loughran and McDonald (2016) flagged that text can convey incremental information thereby resulting in market predictability. Since the literature regarding news announcement on carbon markets is scarce, we have resorted to existing studies in energy and commodity markets. The similarity and spillover amongst energy, commodity and carbon markets have been vastly studied which strengthen the stance for this reference.

Sentiment analysis is an increasing area of research and application, due to the sheer size of unstructured data that is now available. Two distinct types of sentiment analysis have been brought forward namely; direct measure of sentiment through survey or indirect ones through proxies or text mining Chowdhury et al. (2014). This method has been further expanded into Rule-based methods (relying on small set of rules for short text sources), Dictionary-based approaches (count the frequency of pre-defined positive and negative words), Term-weighting approaches (use word frequencies from a training set to assign weight to each term) and Machine-learning approaches.

Sinha (2016) find that the US stock market had under reaction to the tone of news articles. Santi (2020) gather climate related news from StockTwits from 1 January 2010 to 30 September 2019 to build a measure of investor's climate sentiment using the R package Sentimentr. The sentiment is then regressed against carbon prices, oil prices and performance of market portfolio. The study accounts for international events such as UN Summits on climate change, global climate strikes and international environmental policies being rolled out. Kuttner (2001) introduces the policy surprise measure to capture the unexpected target rate change of the market. The expected policy rate change is computed as the policy rate change minus the unexpected policy rate change. Rad (200) uses agency news to train Support Vector Regression that predicts the magnitude of price changes but the latter did not evaluate the impact of news.

[1] https://www.businessgreen.com/news/2033960/carbon-price-spikes-japan-nuclear-crisis

Belgacem et al. (2015) collect American economic announcements from Bloomberg to assess their effect on oil and stock markets. They separate the expected and unexpected component of the news through surprise as the difference between real change of the indicator value from the market consensus forecast (Fleming and Remolona, 1997). López (2018) conduct a regression analysis on oil price indices based on dummy variables for ten news announcement items such as CPI, GDP, Producer Price Index amongst others.

The sporadic growth of carbon markets around the world give rise to assess the impact of international related news on the latter. The EU ETS has been dominating and has thrive as the largest carbon market over the years. However, the remarkable performance of other carbon markets should not be ignored. For instance, the Chinese pilot ETS has had an overall compliance ration of over 99 percent and have witnessed a trading volume exceeding 347 million tons of carbon dioxide equivalent at the end of 2019 Lu et al. (2021).

2.4 Computation of Sentiment Score

We crawl daily carbon market related news from Bloomberg Environment and Carbon Market sections for the period January 2015 until June 2020. A total number of 60,848 news headlines were screened (refer to Table 1). The news are provided by Bloomberg Intelligence, Carbon Pulse and other independent news reporters. Carbon Pulse provides in-depth news and intelligence about global carbon pricing schemes and climate change policies. The choice for Bloomberg news stems for the following reasons: (1) Bloomberg conveys news about carbon markets and provides a detailed coverage of related events. (2) Bloomberg news is a third-party content and thus, do not originate from market participants themselves. (3) Announcements from Bloomberg comprises of novel information solely compared to other sources that tend to edit, perturbed or shortened the content through editors. Overall, Bloomberg news provides the advantage of a more objective news source. The market participants usually receive the real time message in the form of email from Bloomberg. Instead of full news articles, we used the headlines as they contain much less repetition and irrelevant words than the article itself (Nassirtoussi et al., 2015) and (Li et al., 2021).

The announcements comprised of label or headings that indicated their content. Based on those headings, the news has been filtered such that we extract announcement focusing on carbon markets solely. A set of filter criteria has been applied: (1) news in english only has been screened. (2) the selected headings were opened and read through to ensure we capture all information and not just an alert. (3) Special types of announcements such as

alerts or personal opinions have been eliminated given the limited relevance to changes in carbon markets. (4) we excluded the news related to prices to avoid simultaneity (Antonakis et al, 2010; Antonakis et al. 2014).

Table 1: News headlines screened per month

Month	2015	2016	2017	2018	2019	2020
January	389	436	469	475	504	735
February	722	648	748	585	820	872
March	918	752	953	882	976	1010
April	854	848	721	624	977	831
May	861	830	724	618	966	744
June	813	952	664	567	875	740
July	860	753	687	556	843	
August	640	751	508	633	793	
September	1035	735	534	688	890	
October	721	584	588	664	833	
November	923	721	793	744	793	
December	770	712	504	553	831	
Total number of news headline	11521	10738	9910	9607	12120	6952

Table 2: News headlines related to carbon markets per category

Category	**Total**
International Announcements	153
Controversies and Uncertainty	39
Linkage	18
Lobbying	20
Market Reforms	23
New Carbon Markets	13
Paris Agreement and Carbon Markets	26
Policy Makers' Ambition	14

For the purpose of this study, we adopted the package Sentimentr (Rinker, 2019) which has already been tested in the energy and climate related studies by Santi (2020) and Ikoro et al. (2018). The package enables us to calculate text polarity sentiment in an accurate way. The use of valence shifters, negators, amplifiers/deamplifiers ultimately help to increase or reduce the impact of a polarized word. The sentiment value of each headline is calculated using a mathematical formula called P/N ratio where it uses the number of positive and negative sentences obtained from the sentence polarity identification task. However, we observed that the sentiments performed well at detecting the negative words but lagged behind for the positive and neutral words. Thus, we analysed the polarity level from high frequency words and amended the lexicons of those words in the package. Words such as 'backing', 'transparency', 'implement', 'pledge', 'commit', 'plan', 'add', 'install' and 'control' were then treated as posi-

tive rather than neutral. Finally, the number of news stand as follows: 52 Good news, 46 Bad news and 55 Neutral news.

3 Methods and Data

3.1 Data Collection

Despite that there are several carbon markets around the world, accessing data is still a challenge. We have been able to retrieve data only for 8 ETS as described below. The EU ETS was launched in 2005 followed by the New Zealand ETS in 2008 and then the Chinese seven Pilot ETS of Shenzhen, Beijing, Shanghai, Tianjin, Guangdong, Hubei and Chongqing launched successively since 2013. We used the prices from EU ETS spot prices from Intercontinental Exchange (ICE), Chinese Pilot ETS prices from ICAP, RGGI and California ETS prices from Argus spot prices and South Korean ETS from ICAP. Mizrach and Otsubo (2014) stipulate that ICE ECX provides between 75 to 88 percent of price discovery for EU ETS trading. The seven Chinese pilot ETS did not start at the same date and for this reason, there is a gap in data availability. For the purpose of this study on the following Chinese pilot ETS have been chosen; Guangdong, Hubei and Shenzhen. We resorted to the use of spot prices in the study given that some carbon markets do not issue future contracts yet (for e.g Chinese pilot ETS and South Korean ETS). Raw data R_t are transformed into a stationary series of percentage rate returns (r_t):

$$r_t = ln(\frac{R_{t+1}}{R_t}) * 100 \tag{3.1}$$

3.2 Event Study Methodology

We analyse the effect of announcements on carbon markets using event study methodology (ESM), as outlined in Ball and Brown (2014) and Fama et al. (1969). We opt for the ESM because of its precision in identifying the reaction of an asset following an event. The approach is grounded in the fact that the effect of announcements is analyzed during periods when news enters the market and avoids extended period without announcements (Drake et al., 2011). Further, in contrast with time-series methods, the ESM allows to focus on examinations of

specific events that are isolated from other unwanted news disturbances (noise) that occur outside the event window (Fatum and M. Hutchison, 2003). Thus, the ESM avoids the problem of noise affecting the precision of time series approach. The event methodology has been adopted in previous studies related to energy markets and energy related news, see Halova et al. (2014); Ji and Guo (2015); Chebbi (2018); Berk and Rauch (2016); Capelle-Blancard and Petit (2019).

The initial task of conducting an event study is to define the event of interest and to identify the period over which the carbon price will be examined e.g an event window. In this paper, the carbon prices and events are defined as the unexpected component of the news announcements. The effects of such events is hypothesized to materialize in abnormal returns that are studied with respect to pre-event and event windows. In this paper; (1) event definition: the events are defined by the announcements that are released. (2) event day: the event day is the day on which an announcement was published on Bloomberg. (3) definition of event window: The key element of an event study is the appropriate choice of pre-event and event windows, and typically the estimation window and the event window do not overlap. It is customary to define the event window as larger than the event window. The adoption of long event windows can violate the assumption of market efficiency (McWilliams and Siegel, 1997). Hence, we use event windows of 2 days before and 2 days after the announcements for our analysis. The event window is defined as a five- day period, the event day and two days prior and after the event, which is expressed as [0,0], [-2,0] and [0,2] respectively.

Further, we carefully check the event windows in our analysis for confounding, carbon related news that might affect the carbon prices response instead or in addition to the announcements from the categories being investigated. When analyzing the results, we carefully examine if our results are driven by confounding events and mention this if necessary.

3.2.1 Abnormal Returns

Abnormal returns are defined as the difference between actual returns and their expected values. Hence, for the ith event and time t the abnormal return AR_{it} is defined formally as follows:

$$AR_{it} = r_{it} - E[r_{it}/X_{it}] \tag{3.2}$$

where, r_{it} denotes the actual return and $E[r_{it}/X_{it}]$ denotes the expected return, given the conditioning information X_{it} for the expected return model. We calculate expected returns from a model estimated on the basis of the returns before materialising the event window. All computations are based on log returns computed on close prices. When estimating the expected returns $E[r_{it}/X_{it}]$, we test the carbon prices' returns for auto correlation and heteroscedasticity over all periods (pre event plus windows) associated with the ith event. As auto correlation and heteroscedasticity are largely present in the return, we employ an auto-regressive model. Hence, the expected returns are derived based on the following auto regression:

$$r_{it} = \mu_i + \sum_{k=1}^{p} \beta_k R_{i,t-k} + V_{it} \tag{3.3}$$

with μ_i a constant and V_{it} an error term.It is estimated separately for each day i with individual lag length p determined by the Bayesian Information Criterion of Schwarz (1978). AR_{it} signals the informational content of the event on day t; if informative, it would significantly drive the price of allowances.

We sum up all the AR from $T_1; T_2$ i.e starting and ending day of the event window to obtain the cumulative abnormal return CAR.

$$CAR_i(T_1; T_2) = \sum_{j=T_1}^{T_2} AR_{ij} \tag{3.4}$$

We then compute the cumulated average abnormal return $CAAR(T_1; T_2$ by calculating the average of all $CAR_i(T_1; T_2)$:

$$= \frac{1}{N} \sum_{i=1}^{N} CAR_i(T_1; T_2) \tag{3.5}$$

where N is the number of events. Finally we test the hypothesis of whether $CAAR_i(T_1; T_2)$ is different from zero. We calculate its t-statistic and then compare it to the critical value.

$$t = \frac{CAAR(T_1, T_2)}{\sqrt{\frac{(T_2 - T_1 + 1)\sum_{i=1}^{N} \hat{\sigma}_i^2}{N^2}}} = N(0,1) \tag{3.6}$$

In this paper, we use the critical value of 1.645, 1.96, and 2.576 of a normal distribution with a two-sided test associated with significance levels equal to 10%, 5% and 1%, respectively.

3.3 Testable Hypotheses

Hypothesis 1 : News announcements on carbon markets do not affect the value of carbon prices on emission trading systems.

Hypothesis 2 : There is no difference among types of news announcements with respect to their effect on the value of carbon prices on emission trading systems.

Hypothesis 3 : There is no difference in the market reaction before and after news announcements.

4 Empirical Results

In this section, we start by discussing the findings from the event study for each category of news followed by the type of news.

Table 3 represents the impact of controversial and uncertainty news on CAAR.The type of news in this category relates mostly to governing controversies over the effectiveness of carbon pricing, ambiguity over the host countries of carbon markets' ambitions to meet the Paris Agreement, carbon leakage highlights or countries raising concerns over the ETS mechanisms. The immediate effect can be felt in the Chinese ETS whilst for the Californian ETS, it is felt one day after the event, likewise for RGGI. The controversies do not seem to impact the EU ETS. Quebec and South Korean ETS speculate the news on day prior to the event and the impact is felt two days post event. Previous studies by Golub et al. (2017) found that prices usually jump in an era of controversies and uncertainty. The oldest ETS; EU, California and RGGI are more resilient to such controversies compared to the latest ones in China. Additionally, controversies and uncertainty negatively impacts on carbon returns which supports existing

studies. The results are in line with Adedoyin and Zakari (2020) confirming that uncertainties decreases economic growth and consumption thereby plunging the CO2 emissions and prices.

Table 3: Controversial and Uncertainty News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	0.050	0.014	-0.002	-0.093	-0.005
	(3.303)***	(1.113)	(-0.233)	(-5.33)***	(-0.246)
EUA	0.086	-0.021	0.001	-0.052	-0.001
	(1.558)	(-0.476)	(0.041)	(-0.814)	(-0.016)
RGGI	-0.095	-0.088	-0.001	-0.134	-0.012
	(-0.412)	(-2.766)***	(-0.026)	(-2.960)***	(-0.247)
Quebec	0.020	0.071	-0.001	-0.011	-0.099
	(1.049)	(4.538)***	(-0.049)	(-0.475)	(-4.009)***
South Korea	0.064	-0.088	-0.011	-0.287	-0.268
	(1.807)*	(-2.766)***	(-0.555)	(-0.142)	(-5.888)***
Guangdong	-0.067	0.072	-0.188	-0.084	0.171
	(-0.852)	(1.115)	(-4.126)***	(-0.920)	(1.671)*
Hubei	0.364	0.399	-0.188	-0.084	0.219
	(4.825)***	(6.482)***	(-4.126)***	(-0.920)	(2.247)***
Shenzhen	0.636	1.135	-0.562	0.090	0.433
	(1.651)*	(3.612)***	(-2.528)**	(0.202)	(0.872)

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

Table 4 represents the linkage news' impact on CAAR. In the past few years, the conversations of a global carbon market has been on the radar of policy makers. Whilst some of the carbon markets are on the verge of linking their trading activities, this shall have a ripple effect on the pricing. The linkage news relate to announcements of linkage discussions and when a linkage deal has been finalised. Most of the news include linkage about EU ETS and other carbon markets. The findings show that such announcements have an immediate and post effect in the EU ETS with high statistical significance along with positive impact on CAAR. RGGI has also registered high statistical significance on linkage announcements, however unlike EU ETS, a negative impact can be witnessed. California and Quebec ETS are not affected by the linkage announcements despite that their goals have been tied in 2016, which falls under the time period assessed. Compared to other ETS, no news was related to South Korea forging linkage with other carbon markets which in turn reflects in the findings. There

is no impact of such news on the event and post event-days. China has also been involved in diplomatic discussions to link their ETS and these have transcended into significant impact on the announcement day for Guangdong and Hubei.The findings comply with that of Alexeeva and Anger (2016) who find that linkage eventually leads to a disadvantage to non EU ETS. With the advent of Article 6 of the Paris Agreement, which has been finalised in COP26 in late 2021, such effect of linkage can impede on carbon pricing differently in the near future. It is only now that the work programme to transfer international mitigation outcomes shall be build upon. Therefore, we can expect more conversations to come up on linking carbon markets and eventually impacting on their mechanisms and pricing.

Table 4: Linkage News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.005	-0.009	-0.016	-0.007	-0.003
	(-0.302)	(-0.694)	(-1.829)*	(-0.382)	(-0.158)
EUA	0.157	-0.119	-0.098	0.229	-0.127
	(2.861)***	(-2.649)***	(-3.068)***	(3.603)***	(-1.786)*
RGGI	-0.008	0.000	0.344	-0.159	-0.142
	(-0.206)	(-0.014)	(15.245)***	-(3.528)***	(-2.814)***
Quebec	-0.030	-0.029	-0.007	-0.001	-0.006
	(-1.552)	(-1.867)*	(-0.604)	(-0.038)	(-0.241)
South Korea	0.123	-0.089	-0.008	-0.039	-0.035
	(3.491)***	(-3.073)***	(-0.395)	(-0.964)	(-0.767)
Guangdong	-0.050	0.154	-0.219	-0.226	-0.019
	(-0.637)	(2.392)**	(-4.794)***	(-2.480)**	(-0.184)
Hubei	0.054	-0.081	-0.158	0.315	0.180
	(0.722)	(-1.310)	(-3.629)***	(3.621)***	(1.845)*
Shenzhen	0.069	0.370	-0.336	0.161	-0.224
	(0.180)	(1.177)	(-1.510)	(0.362)	(-0.450)

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

Carbon markets have been the prey of lobbying by different stakeholders. Table 5 represents the impact of lobbying on CAAR. The news relate to stakeholders such as non-governmental organisations and companies lobbying for an effective carbon pricing. Most announcements comprise of EU ETS. Significant impact has been registered in EU and RGGI, the oldest ETS. It can be noted that such lobbying in European or US arena transcends to the Chinese ETS but not to others. China is on the league to overcome EU ETS and as such, lobbying news

might be taken into consideration in those markets. There is no previous that quantifies the impact of lobbying news on carbon prices. The findings contribute to literature.

Table 5: Lobbying News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.003	0.002	-0.011	-0.015	-0.007
	(-0.185)	(0.137)	(-1.239)	(-0.840)	(-0.366)
EUA	0.056	0.107	0.133	0.208	0.213
	(1.014)	(2.372)*	(4.200)***	(3.272)***	(3.003)***
RGGI	0.043	-0.024	-0.141	-0.241	-0.285
	(1.089)	(-0.748)	(-6.222)***	(-5.343)***	(-5.641)***
Quebec	0.004	-0.001	0.017	0.020	0.008
	(0.220)	(-0.061)	(1.524)	(0.922)	(0.337)
South Korea	0.077	0.050	-0.008	0.051	0.057
	(2.181)***	(1.720)*	(-0.378)	(1.249)	(1.260)
Guangdong	-0.177	-0.013	-0.111	-0.125	-0.136
	(-2.241)**	(-0.201)	(-2.432)	(-1.365)	(-1.328)
Hubei	0.085	-0.114	-0.478	-0.488	-0.274
	(1.121)	(-1.855)*	(-10.968)***	(-5.598)***	(-2.811)***
Shenzhen	1.268	0.131	1.351	0.464	0.098
	(3.294)***	(0.416)	(6.080)***	(1.043)	(0.198)

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

Market reforms have been the favorite amongst previous studies. It can be noted from the findings that market reforms have an immediate impact on the announcement day on all carbon markets. The finding is highly correlated with that of MacKenzie (2009); Lepone et al. (2011); Fan and Todorova (2017); Tan and Wang (2017b). It can also be deduced that such announcements are foreseen by the market and thus portrays that information disclosure has already taken place in such cases. No post announcement impact has been registered from market reforms communications. Ren and Zhu (2020) who studied the announcement of market reforms in Chinese carbon markets found that the effect last 43 days prior to the announcement and disappear 13 days post it. The latter also confirms that compared to the impacts in the previous compliance periods, the impacts in the latter two periods were shorter-lived and stronger. Similarly, the findings show that market reforms announcement impact are short lived now. Unlike the other ETS, the EU one has registered a negative impact from market reforms. This can be related to the intense discussions and negotiations on the market

reforms by large number of countries for the EU ETS compared to other ETS which are mostly nationally governed and regulated with less intervention from stakeholders.

Table 6: Market Reforms News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.092	-0.228	0.195	0.078	0.102
	(-6.143)***	(-18.514)***	(22.428)***	(0.000)	(0.000)
EUA	-0.242	-0.330	-0.079	-0.768	-0.633
	(-4.398)***	(-7.347)***	(-2.490)**	(-0.012)	(-0.009)
RGGI	-0.150	-0.116	0.128	0.089	0.264
	(-3.825)***	(-3.624)***	(5.665)***	(0.001)	(0.003)
Quebec	-0.097	-0.275	0.203	-0.022	-0.043
	(-5.045)***	(-17.580)***	(18.349)***	(0.000)	(0.000)
South Korea	-0.093	-0.257	-0.158	-0.238	-0.226
	(-2.637)***	(-8.916)***	(-7.733)***	(-0.002)	(-0.002)
Guangdong	0.014	0.272	0.121	0.340	0.257
	(0.173)	(4.214)***	(2.651)***	(0.008)	(0.005)
Hubei	-0.087	-0.089	0.213	0.081	0.167
	(-1.147)	(-1.443)	(4.884)***	(0.002)	(0.003)
Shenzhen	0.058	-0.297	0.608	0.179	-0.550
	(0.150)	(-0.945)	(2.736)***	(0.020)	(-0.055)

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

There are around 13 announcements related to introduction of carbon market in the past five years. The new carbon markets stem from diverse regions such as Kenya, Mexico, India, Nova Scotia and Indonesia. The aviation carbon offsetting program has also been in the highlights as well as the voluntary carbon market of indigenous group. The introduction of new carbon markets has an immediate impact on the oldest ETS such as EU, California, Quebec and RGGI whilst the latest ones mainly from Asia are not impacted. South Korea, Guangdong and Hubei has registered significant impact prior and post the announcement. RGGI speculates such news compared to EU and California which only experience event day impact. The EU ETS and Quebec have registered negative impact from new carbon market compared to RGGI and California experiencing positive impact. This disparity can also be due to existing and foreseen linkage between carbon markets. EU is a step forward in linking with other carbon markets such as Norway, Switzerland and Australia compared to other carbon

markets. Thus, market participants are likely to reach to introduction of new carbon market as it can ultimately influence trading through linkages.

Table 7: New Market News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.005	-0.004	0.020	0.024	0.038
	(-0.333)	(-0.339)	(2.302)**	(1.389)	(1.955)*
EUA	-0.024	0.002	-0.152	0.031	0.087
	(-0.428)	(0.049)	(-4.797)***	(0.485)	(1.231)
RGGI	-0.220	-0.488	0.260	-0.182	0.004
	(-5.625)***	(-15.286)***	(11.505)***	(-4.036)***	(0.071)
Quebec	-0.004	0.011	-0.021	-0.013	0.008
	(-0.220)	(0.674)	(-1.900)*	(-0.570)	(0.312)
South Korea	0.091	0.157	-0.021	0.165	0.099
	(2.575)***	(5.441)***	(-1.006)	(4.060)***	(2.164)
Guangdong	0.093	0.188	-0.053	0.284	0.307
	(1.176)*	(2.913)***	(-1.158)	(3.115)***	(3.011)***
Hubei	-0.588	-0.579	-0.052	-0.579	-0.523
	(-7.790)***	(-9.404)***	(-1.188)	(-6.644)***	(-5.369)***
Shenzhen	0.300	-0.174	-0.180	-0.168	-0.198
	(0.780)	(-0.554)	(-0.810)	(-0.377)	(-0.398)

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

Literature has shed light on the influence of politics on carbon markets especially since the ones studied are government led. The news related to policy makers ambitions' relate to the government putting forward their climate mandate and especially increase their target. The news have been restricted to countries that already have a carbon market established or scheduled. In EU, the policy makers ambitions' matters since an immediate effect is noted. Similarly, the Chinese ETS record significant impact of the policy makers ambitions. RGGI and California are not impacted by such news. It might be due to the uncertainty that reigns in the government target. For example, US withdrew from the Paris Agreement just four days after it entered into force in November 2016. The latter also dropped out of the Kyoto Protocol in 2001. Despite the resistance to commit to international agreements, the US has adopted carbon pricing mechanisms and policy makers' ambition do not seem to influence their trading activities.

Paris Agreement ratified during COP21 has been on the headlines for the period assessed from 2015 to 2020, mostly due to recurrent negotiations in every COP since 2015. It brought

Table 8: Policy Makers Ambitions' Impact on CAAR

Carbon market	-2	-1	0	1	2
California	0.020	0.020	0.006	-0.002	-0.009
	(1.322)	(1.645)*	(0.702)	(-0.109)	(-0.482)
EUA	-0.067	-0.110	-0.070	-0.318	-0.230
	(-1.225)	(-2.452)**	(-2.202)**	(-5.002)***	(-3.235)***
RGGI	-0.029	-0.015	-0.006	0.024	0.023
	(-0.748)	(-0.475)	(-0.251)	(0.540)	(0.450)
Quebec	0.015	0.035	0.015	0.018	0.009
	(0.783)	(2.268)**	(1.350)	(0.826)	(0.365)
South Korea	0.076	0.131	0.011	-0.038	0.007
	(2.152)**	(4.553)***	(0.544)	(-0.932)	(0.163)
Guangdong	0.018	0.060	0.153	0.239	0.387
	(0.228)	(0.930)	(3.359)***	(2.620)***	(3.790)***
Hubei	0.165	0.149	0.075	0.074	-0.065
	(2.189)**	(2.421)**	(1.730)*	(0.851)	(-0.664)
Shenzhen	-0.369	-0.741	-1.054	-1.255	-1.997
	(-0.958)	(-2.356)**	(-4.744)***	(-2.824)***	(-4.019)***

The figures represent the CAAR and the t-statistics in bracket. The symbols *, ** and *** denote statistical significance at 10% , 5% and 1% levels respectively.

along several implications for carbon market environment such as Article 6 dealing with international transfer of mitigation outcomes, talks about global carbon market or even market clubs. News related to the Paris Agreement significantly impact most carbon markets except for Guangdong and Shenzhen. EU ETS registers the highest positive impact on its CAAR. On the contrary, California and Quebec register negative jump in their CAAR whilst RGGI has a minor positive impact. South Korea has noted significant impact pre and post annoucement of news related to the Paris Agreement. It is worth filing this disparity on the impact registered.

Following the different categories of news, it is also important to look at the type of news and their impact on carbon pricing. As mentioned in section 2, sentiment of news study on carbon markets is scare and the findings from this paper is a contribution to literature. We segment the type of news using the sentiment score from the R sentiment analysis package and thereon segregated into good, bad and neutral news. The difficulty in studying the impact of sentiment on energy commodities lies not only in finding an appropriate proxy for the sentiment but the lack of theoretical understanding on the relationship between sentiment and energy markets (Maslyuk-Escobedo et al., 2017). As a first snapshot of the types of news, it

Table 9: Paris Agreement News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.017	-0.026	-0.032	-0.066	-0.071
	(-1.102)	(-2.099)**	(-3.703)***	(-3.774)***	(-3.661)***
EUA	0.013	-0.138	0.174	-0.059	-0.164
	(0.227)	(-3.060)***	(5.482)***	(-0.934)	(-2.311)**
RGGI	0.141	0.126	0.095	0.111	0.124
	(3.602)***	(3.946)***	(4.194)***	(2.449)**	(2.452)**
Quebec	-0.003	-0.029	-0.033	-0.066	-0.060
	(-0.173)	(-1.853)*	(-2.957)***	(-2.965)***	(-2.437)**
South Korea	0.022	0.060	0.057	0.149	0.148
	(0.610)	(2.089)**	(2.808)***	(3.661)***	(3.241)***
Guangdong	-0.439	0.225	0.062	0.137	0.305
	(-5.552)***	(3.489)***	(1.355)	(1.500)	(2.990)***
Hubei	0.135	0.221	0.147	0.136	0.136
	(1.786)*	(3.590)***	(3.364)***	(1.563)	(-1.490)
Shenzhen	1.162	0.428	0.138	0.319	1.066
	(3.019)***	(1.361)	(0.623)	(0.718)	(2.145)**

can be deduced that all three categories significantly impact the abnormal returns. Such effect can cause prices to deviate from their fundamental values.

Good news have significant immediate impact for all carbon markets except for Hubei. The good news have caused positive abnormal returns for most carbon markets except Guangdong which registers a negative CAAR on the announcement day. However, the returns turn out to be positive post announcements for Guangdong. Such good news also have an impact over the 5 window days being investigated which indicates that it is anticipated. Existing studies on commodity markets state that returns tend to be more sensitive to downward sentiment rather than upwards one.

Bad news influence all carbon markets significantly and negatively which is aligned to literature as negative sentiments tend to lower prices. Higher impact of such news is felt in the Asian markets such as South Korea. Guangdong and Shenzhen compared to EU and California. Once again, we can debate on the existence and the resilience of the carbon markets towards bad news. Previous studies on commodity markets reported stronger effect of bad news over good news (Dzielinski, 2011; Smales, 2015). However, the findings showcase that

Table 10: Good News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.063	-0.266	0.18	-0.042	-0.118
	(-4.157)***	(20.717)***	(-21.597)***	(-2.801)***	(-6.049)***
EUA	-0.126	-0.256	0.132	0.02	-0.252
	(-2.297)**	(-5.695)***	(4.147)***	(0.37)***	(-3.546)***
RGGI	0.058	-0.035	0.137	0.169	0.019
	(1.493)	(-1.093)	(6.051)***	(4.312)***	(0.378)
Quebec	-0.102	-0.341	0.196	-0.073	-0.186
	(-5.325)***	(-21.806)***	(17.717)***	(-3.809)***	(-7.534)***
South Korea	-0.098	0.13	0.282	0.052	-0.113
	(8.00)***	(4.504)***	(-4.831)***	(1.473)	(-2.49)**
Guangdong	0.155	0.418	-0.435	0.566	0.355
	(-5.501)***	(6.481)***	(3.392)***	(7.159)***	(3.475)***
Hubei	0.148	-0.42	-0.021	-0.382	-0.469
	(1.958)**	(-6.828)***	(-0.489)	(-5.067)***	(-4.814)***
Shenzhen	1.289	-0.134	0.644	0.559	-0.09
	(3.349)***	(-0.428)	(2.899)***	(1.454)	(-0.181)

bad news are most likely to have an immediate effect rather than a prolonged one. Dzielinski (2011) notes that negative news resolves asymmetric information on average, whilst positive news does not.

Neutral news comprise of news that are around zero. Neutral news significantly impact the carbon markets on the announcement date except for Quebec and Shenzhen. The effect is felt one day before, on event day and one day post announcement. The magnitude of impact differs across carbon markets. The EU ETS and California have registered negative returns.

From the findings, it can be deduced that the type of news matters in carbon markets. The degree of impact differs from literature. Whilst existing studies forecast higher impact from bad news for commodity markets, it is the contrary for carbon markets. This might be due to the nature and source of news. Most bad news are related to lobbying and controversies. Based on the results, controversies, uncertainty and lobbying by stakeholders do not significantly impact on carbon price. Thus, this is reflected in the lower impact of negative news.

Table 11: Bad News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	-0.019	-0.007	-0.051	-0.05	0.041
	(-1.243)	(-0.542)	(-5.877)***	(-3.318)***	(2.093)**
EUA	0.055	0.038	-0.062	-0.083	0.043
	(1.002)	(0.838)	(-1.962)**	(-1.501)	(0.608)
RGGI	0.026	0.104	-0.194	-0.214	-0.135
	(0.669)	(3.26)***	(-8.591)***	(-5.472)***	(-2.674)***
Quebec	-0.045	-0.02	-0.04	-0.047	0.005
	(-2.328)**	(-1.257)	(-3.641)***	(-2.448)**	(0.199)
South Korea	0.179	0.265	-0.215	0.005	0.047
	(5.085)***	(9.214)***	(-10.55)***	(0.148)	(1.023)
Guangdong	-0.1	0.388	-0.511	0.07	0.092
	(-1.266)	(6.017)***	(-11.191)***	(0.884)	(0.905)
Hubei	0.335	0.256	0.075	0.209	-0.029
	(4.444)***	(4.164)***	(1.713)*	(2.770)***	(-0.293)
Shenzhen	-0.028	1.484	-1.094	-0.522	-0.965
	(-0.073)	(4.721)***	(-4.925)***	(-1.357)	(-1.942)*

Table 12: Neutral News Impact on CAAR

Carbon market	-2	-1	0	1	2
California	0.015	0.009	-0.052	-0.124	-0.143
	(0.965)	(0.708)	(-5.993)***	(-7.153)***	0.011
EUA	-0.052	-0.299	-0.137	-0.534	-0.493
	(-0.945)	(-6.647)***	(-4.318)***	(-8.408)***	(0.051)
RGGI	-0.330	-0.567	0.638	-0.192	-0.125
	(-8.443)***	(-17.737)***	(28.253)***	(-4.248)***	(-0.002)
Quebec	-0.018	0.064	0.034	-0.088	-0.084
	(1.763)*	(4.100)***	(-1.606)	(-3.967)***	(0.023)
South Korea	-0.054	-0.183	-0.184	-0.224	-0.310
	(-1.534)	(-6.355)***	(-9.039)***	(-5.493)***	(0.015)
Guangdong	-0.200	0.154	0.125	0.002	0.617
	(-2.530)**	(2.381)**	(2.748)***	(0.020)	(0.100)
Hubei	-0.324	0.141	-0.307	0.259	0.049
	(-4.300)***	(2.284)**	(-7.041)***	(2.976)***	(-0.003)
Shenzhen	1.240	-0.566	0.224	-1.486	-0.746
	(3.223)***	(-1.802)*	(1.006)	(-3.343)***	(-0.332)

5 Conclusion

Although carbon markets are sensitive to the release of news, the way in which this information is received is not at all well studied. Not until recently, researchers have started to look into the content of news stories impact on carbon market from a single stream. In our analysis, we concentrate on seven different categories of news and segregated the type of news; good, bad and neutral. An additional contribution is in terms of investigating eight carbon markets around the world. The findings reveal that carbon prices are less likely to be impacted by negative news which is linked to controversies, uncertainty or lobbying. Good news highly influence carbon prices.

Moreover, the effect differs amongst carbon markets. The EU ETS and RGGI being the largest and oldest one are significantly impacted by all categories of news compared to other carbon markets, especially the Asian one; South Korea and Chinese ETS. The findings on California and Quebec ETS are similar. Their existing linkage could have motivated the results. The oldest ETS are more influenced by the announcements than the latest ones. This can be attributed to the liquidity in the markets as well. RGGI, EU and California are traded on different contracts; both spot and futures. The Chinese ETS and South Korean ETS have recently introduced future contracts. Market participants are more likely to react in highly liquid market.

Compared to other energy commodities, the impact of news announcement are not observed post event day. Likewise, it is not anticipated in most carbon markets. Market reforms is the primary category that experiences prolonged effect because such news are foreseen and discussed before being announced.

This paper opens avenues for future research such that each category can be investigated in depth over a longer period of time. It is also recommended to expand the news content length and study whole publications other than headlines. In addition, the volatility and volume of the returns can be studied. All avenues are part of our research agenda.

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